List of Topics for OU-1 Remedial Investigation Report Focused Workshop: NSA Hydrogeology and Groundwater Chemistry –Natural and Agricultural versus Mine Impacted Water

1. **Groundwater Flow**. The Site Groundwater Flow Model represents the flow of alluvial water from south to north within the regional setting and geologic structure of the Mason Valley alluvial fill on the bedrock structure. The seasonal operation of irrigation wells north of the Site during the growing season of select crops causes changes in the groundwater gradients and flow directions on a temporary basis. Surface irrigation of crops using Walker River water and/or groundwater creates a temporary mound of water below active growing crop areas. It would be beneficial to discuss how Mine Impacted Water (MIW) does not flow into the NSA even though the OU-1 alluvial groundwater system is a single, physically continuous body of water with no barriers that prevent the natural flow of water from south to north.

2. **Groundwater Chemistry**. The Remedial Investigation (RI) report summarizes the investigative work done to characterize the OU-1 groundwater system for understanding the nature and extent of contamination in the alluvial aquifer as it originates beneath evaporation ponds at the Site, and extending as far north as Sunset Hills a distance of approximately 2 miles. The four main MIW identifier chemicals (uranium, sulfate, sulfur-34 isotope, and arsenic) along with other multiple lines of evidence are used to track the presence or absence of any contamination in the alluvial groundwater that is from the Site. In the NSA some monitoring wells show trends of increasing uranium concentration that is interpreted to be a result of agricultural practices, and not due to contamination from MIW that has flowed into the NSA. It would be beneficial to discuss how increasing uranium concentrations in the NSA are due to increased bicarbonate in the water from increased levels of carbon dioxide gas in the crop root zone that are converted to dissolved inorganic carbon to create bicarbonate which then leaches uranium from the soil/sediments. Does the explanation of increasing uranium in NSA groundwater due only to agricultural irrigation-leaching-recharge make sense based on mass balance estimates and source(s) location?

3. **Level of uncertainty with interpretation and monitoring in NSA –adequate to support the RI?** OU-1 is subdivided into three smaller study areas with two areas, the South West Recharge Area (SWRA) and the South East Recharge Area (SERA) hosting monitoring well networks designed to characterize the nature and extent of Mine Impacted Water (MIW). The third study area, the North Study Area (NSA) has approximately 13 well clusters and 8 single wells. The NSA monitoring well network was not designed to monitor the presence or absence of MIW although it does perform this function with a lower level of certainty than the SWRA and SERA networks. The NSA was designed to monitor agricultural inputs to the groundwater system up gradient of the NSA and beyond the furthest northern extent of the MIW plume. Unfortunately, not all of the hydrologic source term inputs from natural (soil and Walker River) and/or agricultural practices (soil amendments, fertilizer) that could introduce uranium, sulfate (SO_4), nitrate (NO_3), bicarbonate (HCO_3) to groundwater in the NSA have been adequately characterized. Characterization depth profile data was collected during the

installation of some of the NSA well clusters, but there are large areas without data. The Remedial Investigation cites published literature on the Walker River natural uranium content (Benson and Leach, 1980), and analog site groundwater studies to interpret the increased uranium levels with respect to complexation with HCO_3 due to irrigated soil leaching of natural uranium. In the Appendix C-1 Hydrologic Tracer – Supplemental Information report, samples of soil, soil amendment, and fertilizer being used at the Hunewill Ranch were tested for values of $\delta^{34}S$ and $\delta^{18}O$ isotopes (see Table C-4). Has there been adequate testing of fertilizer samples used by growers in the NSA for sulfur and oxygen isotopes for characterizing the isotopic input from this source compared to the +4.93 to +6.62 per mill $\delta^{34}S$ range that identifies the presence or absence of MIW? Has the uranium content of the soil in the NSA been tested for leachable uranium at levels and locations that support the interpretation that increasing levels are not related to MIW?

In an article by Vitoria, Otero, Soler, and Canals (2004) that studied the isotopic composition of fertilizer (N, S, O, C, and Sr); the isotopic composition of sulfur in synthetic fertilizers comes from two major sources, sulfuric acid and marine evaporites. Usually metal sulfides, sulfates, sulfurous gases, and native sulfur are the raw materials used in the production of sulfuric acid. The sulfuric acid will inherit the isotopic signature of the source materials and so does the fertilizer which can display a range of $\delta^{34}S$ values that are mostly positive but variable. Given that the sulfur isotopic identifier of MIW is between the +4.93 to +6.62 per mill range, will this isotopic identifier range be a reliable indicator over a long time period (>20 years?) Will this isotopic range identifying characteristic become more unreliable with time and distance from the mine site? It would be beneficial to discuss how sources of contaminants-isotopic identifiers of MIW, and alternative sources (Walker River, soil, fertilizers, soil water) have been adequately sampled and characterized in the NSA to an acceptable level of certainty to ensure credible interpretation and monitoring of the true extent-position of MIW plume(s).

4. **Size of OU-1, too large to manage?** The size of OU-1 at approximately 10 square miles of area is so large that the density of data points (monitoring wells and/or private wells) is lacking or absent creates areas where a higher level of uncertainty exists regarding the character of the groundwater system with respect to the presence or absence of contaminant sources from the mine, natural, and/or agricultural practices. See Figure 1-2 from the Groundwater Geochemical Characterization Data Summary Report (DSR Revision 1) 12/11/2015. It would be beneficial to discuss the need for the size of OU-1 to be so large with respect to data point density, level of uncertainty, remedy operation, and possible challenges-complications to regulatory closure of such a large operable unit after remedy completion to meet and maintain cleanup standard(s).

5. **Wabuska Drain as a source**
The Wabuska Drain is known to have carried mine waste to an unknown distance from the mine. EPA has proposed extending the study area for OU-7, the Wabuska drain, to Weber reservoir based on both site and historical USGS data. It should also be noted that the statement on page ES-5 (generally repeated on page 22) of the RI:

Results of the ongoing RI for the Wabuska Drain (OU-7) will be reported separately. Available data indicate that concentrations of mine-related chemicals decrease with distance from the Site and depth in the soil profile (EPA 2007, BC 2015b).

Is not consistent with the data from the reports (although those statements are made in the report) as highlighted in EPA, YPT and WRPT comments on those documents. B/W 55, B/W 69 along with YPT MW 11 and 12 could all be part of that discussion but there appears to also be an artificial gap between data generated for OU7 and OU1 that is missing from this discussion.

6. Groundwater and Irrigation near MW-12

Page 92 also highlights the variability of ground water elevation and flow with both season and changes in irrigation practices:

Mounding was most pronounced beneath the Hunewill Ranch fields, and the mound extended beyond the edges of the fields including beneath the Wabuska Drain, which collects and diverts agricultural runoff. The rose diagrams for the Shallow, Intermediate, and Deep 1 zones (Figures 4-11a through 4-11c) indicate that, in both time periods, the mound beneath Wabuska Drain predominantly acted as a groundwater divide, directing recharged groundwater: 1) to the west/southwest beneath the Evaporation Ponds; and 2) to the east/northeast beneath the Hunewill Ranch. The rose diagrams also indicate that, in a small number of months, the groundwater divide was not present and groundwater flow directions were from the east beneath the Hunewill Ranch to the west beneath the Evaporation Ponds. This east-to-west flow predominantly occurred in winter months when irrigation was not occurring.

This condition would also be expected in the area of YPT MW11: there are irrigated fields in the area of similar size and irrigation practice as the Hunewill Ranch. However, in this area there is not adequate wells to assess this issue leaving a data gap as indicated by the distance between B/W 57 and YPT MW11 and 12, a critical area to the current theory on groundwater behavior in the NSA but with a large unmonitored area. Adding to this , B/W 81 and the one well ARC put on the reservation are too new for trend analysis.

Subsequently, the statement in Section 6.2.2:

As indicated in the lower panel, sulfate concentrations in well YPT-MW-12I are greater than 71 mg/L and exhibit seasonal variability, with elevated concentrations occurring in February of each year. Plume advancement cannot account for the magnitude of sulfate concentrations or seasonality observed in this well because sulfate concentrations are lower in wells to the southwest that demarcate the leading edge of mine-impacted groundwater (i.e., well clusters B/W-10, B/W-52, and B/W-55). Instead, the concentrations of sulfate in well YPT-

MW-12I can only be accounted for by sulfate concentrations in upgradient wells B/W-57I and B/W-57D1, which are impacted by agricultural activities.

Still has important data gaps. There is a lack of groundwater elevation and water quality monitoring in the area of the Wabuska Drain and YPT Reservation in the NSA. The Figure 4-11 series showing groundwater elevation contours may not accurately describe the NSA area due to low sampling density. This is also evident by the discussion of how certain regional features such as irrigated fields effect groundwater elevation in other areas but those same explanations are not applied in the NSA.

The use of February data is also notable, is there seasonal trend analysis or similar statistical efforts to support the claim that peaks that time of year are sourced to fertilizer application? Should that not reference actual agricultural practices for those fields? Considering only quarterly data is available and without supporting records of field management, this connection for that particular data point is a theory at best or a good point to initiate further investigation.

7. **Section 6.2.2 states:**

> *The correlation between increasing concentrations of alkalinity and calcium associated with agricultural activities, and increasing uranium concentrations as groundwater flows beneath agricultural fields in the NSA is shown on Figure 6-6.*

This figure actually does not have any trend data so "increasing concentrations" is incorrect, it is correct to say higher concentrations of uranium correlate with higher values of alkalinity for the well data presented. There is peer reviewed literature that indicates that the solubility of uranium can have a positive correlation with alkalinity but that is relatively independent of uranium source. This data comes from a select group of data points whose locations vary considerably when compared to nearby agricultural. From being in or adjacent to agriculture (B/W 57) to relatively far away and deep (B/W 55) where other wells, including B/W 81 that is actually between two irrigated fields, is omitted.

8. **NSA Data Trends**

Trends of uranium and alkalinity (increasing or decreasing according to a Mann-Kendal test presented in Table 1 and Table 2) were only consistent; significantly increasing or decreasing together, in 4 of 22 of NSA wells recently reviewed in the Tribe's comments on the Background Study. However, alkalinity and uranium are increasing together in wells YPT B/W 10D1, 14D1 and 13I, all downgradient of the edge of the discussed plume while both decreasing in 81S which is surrounded by irrigated agricultural fields. This data suggests that the document does not fully explain uranium trends on and near the YPT. Adding to this, wells on the south end of the Reservation not near agriculture have increasing concentrations of uranium, while B/W81S which is located to nearby fields to the east, west and south, actually has decreasing uranium and alkalinity concentrations. B/W 81S is absent from consideration in Figure 6-6.

9. **Incomplete hydrologic tracer analysis for key monitoring wells.**
As indicated in Comment 3, the level of uncertainty in the NSA monitoring well network is recognizable because it was not designed to measure for the presence or absence of Mine Impacted Water (MIW) like the SWRA and SERA networks. Attempts to analyze existing well hydrologic tracer data for the NSA were hampered by the lack of isotopic analysis based on what data is available (see attached table). Perhaps the isotopic data is available? <u>It would be beneficial to have a complete set of isotopic data ($\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, and $\delta^{15}N$) for all NSA wells such that comparisons to those of the SWRA and SERA can be made to further the explanation of increasing trends U, SO_4, NO_3, and HCO_3 as determined and/or inferred can be confirmed with agricultural practices.</u> Attached is a table of incomplete hydrologic tracer results for monitoring wells in and along the boundaries of the NSA that could be sampled and tested for hydrologic tracer analysis.

Table 1. Summary table of Mann-Kendall trend analysis results.

YPT Monitoring Wells (YPT MW)							
Well Number	**Constituents**	**Number of Samples (n)**	**Min**	**Max**	**M-K (S)**	**Approximate p-value**	**M-K Trend**
MW-9I	Alkalinity, Bicarbonate	15	110	150	63	7.17E-04	I
	Alkalinity, Total	15	110	150	63	7.17E-04	I
	Arsenic	15	6.6	7.9	-28	0.0869	NT
	pH	15	7.68	8.11	1	0.5	NT
	Sulfate	15	33	39	-36	0.0392	D
	Uranium	15	8.7	11	18	0.191	NT
MW-10B	Alkalinity, Bicarbonate	15	88	130	35	0.037	I
	Alkalinity, Total	16	88	130	22	0.16	NT
	Arsenic	16	19	21	-7	0.38	NT
	pH	16	8	8.42	20	0.196	NT
	Sulfate	16	25	30	-69	6.12E-04	D
	Uranium	16	8.3	11	-10	0.342	NT
MW-11S	Alkalinity, Bicarbonate	5	120	150	-7	0.0648	NT
	Alkalinity, Total	5	120	150	-7	0.0648	NT
	Arsenic	5	6.3	8.3	-6	0.11	NT
	pH	5	7.3	7.84	-4	0.231	NT
	Sulfate	5	44	64	3	0.307	NT
	Uranium	5	6.6	20	-8	0.0432	D

Key	
Increasing Trend	I
Decreasing Trend	D
No Trend	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

YPT Monitoring Wells (YPT MW)							
Well Number	**Constituents**	**Number of Samples (n)**	**Min**	**Max**	**M-K (S)**	**Approximate p-value**	**M-K Trend**
MW-13I	Alkalinity, Bicarbonate	16	88	140	64	0.00181	I
	Alkalinity, Total	16	88	140	64	0.00181	I
	Arsenic	16	5.8	8.1	56	0.00655	I
	pH	16	7.49	7.93	29	0.103	NT
	Sulfate	16	33	42	-36	0.0553	NT
	Uranium	16	4.6	9.1	95	1.09E-05	I
MW-14D1	Alkalinity, Bicarbonate	16	92	130	38	0.0442	I
	Alkalinity, Total	16	92	130	38	0.0442	I
	Arsenic	16	15	19	-40	0.0352	D
	pH	16	7.61	8.16	-28	0.111	NT
	Sulfate	16	29	38	-12	0.307	NT
	Uranium	16	10	18	47	0.017	I
MW-15I	Alkalinity, Bicarbonate	12	230	340	19	0.105	NT
	Alkalinity, Total	12	230	340	19	0.105	NT
	Arsenic	12	5.7	6.5	-39	0.00363	D
	pH	12	6.82	8.05	-1	0.5	NT
	Sulfate	12	42	56	-13	0.204	NT
	Uranium	12	15	34	10	0.269	NT
MW-12I	Alkalinity, Bicarbonate	16	160	260	38	0.0443	I
	Alkalinity, Total	16	160	260	38	0.0443	I
	Arsenic	16	3.6	5.6	-41	0.0347	I
	pH	16	6.64	7.74	11	0.326	NT
	Sulfate	16	72	270	-34	0.0683	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Off-Reservation Wells (BW)							
Well Number	**Constituents**	**Number of Samples (n)**	**Min**	**Max**	**M-K (S)**	**Approximate p-value**	**M-K Trend**
BW 10D1	Alkalinity, Bicarbonate	41	72	180	310	2.39E-04	I
	Alkalinity, Total	41	72	180	310	2.39E-04	I
	Arsenic	41	7.7	14	-306	2.41E-04	D
	pH	41	7.25	8.33	72	0.212	NT
	Sulfate	41	33	56	414	1.67E-06	I
	Uranium	41	5.4	25	358	2.97E-05	I
BW 10S	Alkalinity, Bicarbonate	30	100	140	47	0.193	NT
	Alkalinity, Total	30	100	140	47	0.193	NT
	Arsenic	29	4.5	6.7	-104	0.0259	D
	pH	30	7.21	8.2	59	0.15	NT
	Sulfate	30	29	120	9	0.443	NT
	Uranium	28	2.4	5.3	-93	0.034	D
BW 53B	Alkalinity, Bicarbonate	20	110	160	28	0.18	NT
	Alkalinity, Total	20	110	160	28	0.18	NT
	Arsenic	20	6.3	16	45	0.0654	NT
	pH	20	7.7	8.18	-49	0.0591	NT
	Sulfate	20	140	170	-47	0.038	D
	Uranium	20	8.8	11	79	0.00464	I
BW 53S2	Alkalinity, Bicarbonate	17	120	140	4	0.446	NT
	Alkalinity, Total	17	120	140	4	0.446	NT
	Arsenic	17	11	15	49	0.00928	I
	pH	17	7.7	8.19	-45	0.0348	D
	Sulfate	17	140	170	-30	0.0943	NT
	Uranium	17	8.4	12	31	0.105	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Off-Reservation Wells (BW)							
Well Number	**Constituents**	**Number of Samples (n)**	**Min**	**Max**	**M-K (S)**	**Approximate p-value**	**M-K Tren d**
BW 54B	Alkalinity, Bicarbonate	15	110	150	3	0.458	NT
	Alkalinity, Total	15	110	150	3	0.458	NT
	Arsenic	15	22	28	3	0.459	NT
	pH	15	7.56	8.2	-20	0.173	NT
	Sulfate	15	63	80	-36	0.0406	D
	Uranium	15	15	20	-11	0.306	NT
BW 54I	Alkalinity, Bicarbonate	15	140	180	7	0.372	NT
	Alkalinity, Total	15	140	180	7	0.372	NT
	Arsenic	15	21	26	-17	0.199	NT
	pH	15	7.93	8.3	-7	0.383	NT
	Sulfate	15	57	73	-36	0.0406	D
	Uranium	15	30	38	-54	0.00379	D
BW 54S	Alkalinity, Bicarbonate	15	140	180	-11	0.292	NT
	Alkalinity, Total	15	140	180	-11	0.292	NT
	Arsenic	15	18	21	3	0.458	NT
	pH	15	7.83	8.21	-5	0.421	NT
	Sulfate	15	41	71	-64	8.46E-04	D
	Uranium	15	20	31	-54	0.00349	D
BW 69D1	Alkalinity, Bicarbonate	6	230	250	-9	0.05	D
	Alkalinity, Total	6	230	250	-9	0.05	D
	Arsenic	6	3.7	4	5	0.205	NT
	pH	6	7.5	8.08	3	0.354	NT
	Sulfate	6	97	120	-9	0.0595	NT
	Uranium	6	50	59	1	0.5	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Off-Reservation Wells (BW)							
Well Number	**Constituents**	**Number of Samples (n)**	**Min**	**Max**	**M-K (S)**	**Approximate p-value**	**M-K Trend**
BW 69D2	Alkalinity, Bicarbonate	6	110	130	1	0.5	NT
	Alkalinity, Total	6	110	130	1	0.5	NT
	Arsenic	6	5.4	5.8	-2	0.421	NT
	pH	6	7.91	8.21	9	0.0664	NT
	Sulfate	6	32	47	1	0.5	NT
	Uranium	6	5.9	11	5	0.226	NT
BW 69D5	Alkalinity, Bicarbonate	5	160	210	-6	0.0958	NT
	Alkalinity, Total	5	160	220	-5	0.156	NT
	Arsenic	5	6.4	13	8	0.0432	I
	pH	5	8.1	8.61	-4	0.231	NT
	Sulfate	5	34	41	9	0.0216	I
	Uranium	5	2.9	4.3	-2	0.403	NT
BW 69S	Alkalinity, Bicarbonate	6	230	280	-6	0.169	NT
	Alkalinity, Total	6	230	280	-6	0.169	NT
	Arsenic	6	1.9	3.1	-8	0.0903	NT
	pH	6	7.22	8.08	7	0.13	NT
	Sulfate	6	120	130	5	0.191	NT
	Uranium	6	7.8	30	-11	0.0301	D

Key	
Increasing Trend	I
Decreasing Trend	D
No Trend	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Off-Reservation Wells (BW)							
Well Number	**Constituents**	**Number of Samples (n)**	**Min**	**Max**	**M-K (S)**	**Approximate p-value**	**M-K Trend**
BW 81D1	Alkalinity, Bicarbonate	5	220	230	-6	0.0745	NT
	Alkalinity, Total	6	220	240	-11	0.0199	D
	Arsenic	6	6.6	7.5	4	0.283	NT
	pH	6	7.43	8.11	7	0.13	NT
	Sulfate	6	68	83	4	0.283	NT
	Uranium	6	36	47	4	0.283	NT
BW 81D2	Alkalinity, Bicarbonate	6	190	200	4	0.244	NT
	Alkalinity, Total	6	190	200	4	0.244	NT
	Arsenic	6	4.1	4.6	0	N/A	NT
	pH	6	7.77	8.15	7	0.13	NT
	Sulfate	6	46	57	6	0.169	NT
	Uranium	6	34	43	12	0.0134	I
BW 81S	Alkalinity, Bicarbonate	5	140	160	-7	0.048	D
	Alkalinity, Total	5	140	160	-7	0.048	D
	Arsenic	5	4.3	5.1	-7	0.0648	NT
	pH	5	7.11	7.8	6	0.11	NT
	Sulfate	5	68	75	5	0.156	NT
	Uranium	4	3	3.9	-6	0.0447	D

Key		
Increasing Trend		I
Decreasing Trend		D
No Trend		NT

Table 2: Summary table of Mann-Kendall trend analysis results from 2002 to 2016 for PW-4 and PW-5 wells.

PW-4 and PW-5 Wells (2002-2016)							
Wells Number	**Parameter**	**General Statistics**			**Mann-Kendall Test**		
		Number of Samples (n)	**Min**	**Max**	**M-K (S)**	**Approximate p-value**	**M-K Trend**
PW5	Arsenic	31	0.016	0.026	-191	4.81E-04	D
	Uranium	24	0.016	0.043	188	1.65E-06	I
	Sulfate	11	54	71	30	0.010	I
	Alkalinity, Total	11	120	140	22	0.0373	I
	pH	11	7.75	8.23	20	0.069	NT
PW4	Arsenic	28	0.008	0.024	-56	0.137	NT
	Uranium	19	0.019	0.047	31	0.146	NT
	Sulfate	7	41	62	-8	0.144	NT
	Alkalinity, Total	7	130	210	3	0.375	NT
	pH	7	7.92	8.56	7	0.184	NT

Key	
Increasing Trend	I
Decreasing Trend	D
No Trend	NT

Table 3 is attached as a Excel Spreadsheet